

CLAIMS

1. A crimped carbon fiber having a multilayer structure comprising an inner layer part and an outer layer part with a hollow structure in the inside thereof, 5 the inner layer part having a carbon structure containing a herringbone structure, the outer layer part having a carbon structure differing from the carbon structure of the inner layer part.

2. A crimped carbon fiber having a multilayer structure comprising a center part and an outer layer part outside the center part with no hollow structure inside thereof, the center part having a carbon structure containing a shape that carbon layers vertical to the carbon fiber axis are stacked, the outer layer part 15 having a carbon structure differing from the carbon structure of the center part.

3. The crimped carbon fiber as claimed in claim 2, wherein the carbon layers vertical to the carbon fiber axis are in a state that each group comprising one or 20 multiple carbon layer(s) is continued or joined at an end face with another group to have a multiply folded and/or ringed cross section.

4. The crimped carbon fiber as claimed in any one of claims 1 to 3, wherein the carbon structure of the 25 outer layer part contains a tree-growth-ring structure.

5. The crimped carbon fiber as claimed in any one of claims 1 to 3, wherein a percentage crimp defined by the following formula is 0.5% or more:

$$\text{Percentage crimp (\%)} = \frac{(\text{fiber length} - \text{distance between fiber terminals})}{\text{fiber length}} \times 100 \quad (1)$$

6. The crimped carbon fiber as claimed in any one of claims 1 to 3, which has a fiber outer diameter of from 2 to 500 nm and a fiber length of 50 μm or less.

35 7. The crimped carbon fiber as claimed in any one of claims 1 to 3, which has an actually measured specific surface area 1.5 times or more the specific surface area

in terms of fiber diameter defined by the following formula (2):

$$\text{Specific surface area in terms of fiber diameter } (\text{m}^2/\text{g}) = 2,000/\text{fiber outer diameter (nm)} \quad (2)$$

5 8. The crimped carbon fiber as claimed in any one of claims 1 to 3, which has a lattice spacing (d_{002}) of 002-plane measured by x-ray diffraction of less than 0.34nm, and a ratio (I_d/I_g) between a peak height (I_d) in a band of $1340\text{-}1349\text{cm}^{-1}$ and a peak height (I_g) in a band of $1570\text{-}1578\text{cm}^{-1}$ of Raman spectrum of more than 0.35.

10 9. The crimped carbon fiber as claimed in any one of claims 1 to 3, which is a vapor grown carbon fiber.

15 10. A carbon fiber mixture comprising 5 vol% or more of the crimped carbon fiber claimed in any one of claims 1 to 3.

20 11. A method for producing the crimped carbon fiber claimed in claim 9, comprising contacting a carbon source and a catalyst source with a sulfur source in a heating zone to produce a vapor grown carbon fiber, wherein the ratio of the molar number of sulfur atom in the sulfur source to the molar number of a catalyst metal atom of the catalyst source is 2.0 or more.

25 12. The method for producing the crimped carbon fiber as claimed in claim 11, wherein the sulfur atom in the sulfur source has a vapor-phase concentration of 0.0001 mol/NL or more in the heating zone.

30 13. The method for producing the crimped carbon fiber as claimed in claim 11, wherein the sulfur source contains at least one member selected from the group consisting of sulfur, thiophene and hydrogen sulfide.

35 14. The method for producing the crimped carbon fiber as claimed in claim 11, wherein the carbon source contains at least one member selected from the group consisting of CO, CO₂, methane, ethane, propane, butane, heptane, hexane, cyclohexane, ethylene, propylene, butadiene, acetylene, benzene, toluene and xylene.

15. The method for producing the crimped carbon

fiber as claimed in claim 11, wherein at least one compound selected from the following groups (A) and (B) is supplied as an addition component to the heating zone:

5 (A) organic compounds in which the lower of the boiling point and the decomposition temperature thereof is 180°C or more,

 (B) organic compound polymers having a molecular weight of 200 or more.

10 16. The method for producing the crimped carbon fiber as claimed in claim 11, wherein the heating zone has a temperature in a range from more than about 1,200°C to about 1,350°C.

15 17. A method for producing a crimped carbon fiber, comprising subjecting the crimped carbon fiber obtained by the production method as claimed in claim 11 further to heating at about 800°C to about 1,500°C in a non-oxidative atmosphere.

20 18. A method for producing a crimped carbon fiber, comprising subjecting the crimped carbon fiber obtained by the production method as claimed in claim 11 further to heating at about 2,000°C to about 3,000°C in a non-oxidative atmosphere.